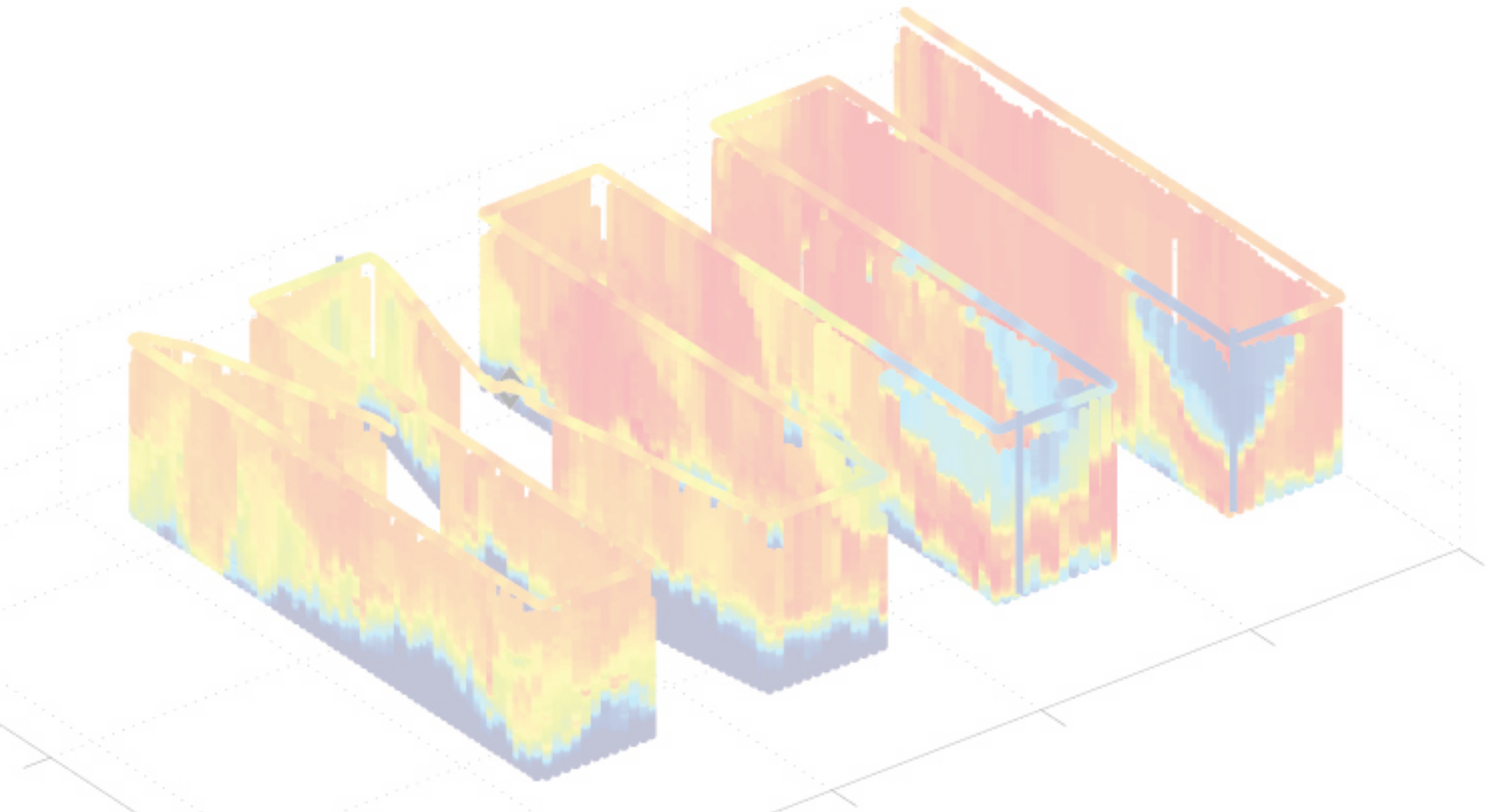
Evidence for the origin of the subsurface salinity maximum in the subtropical North Atlantic

Julius Busecke



Work presented here is in review at JGR: Oceans
Busecke, J., Gordon, A. L., Li, Z., Bingham, F., & Font, J.
Mesoscale turbulence within the subtropical North Atlantic surface layer

Ocean Science Meeting 2014, Honolulu

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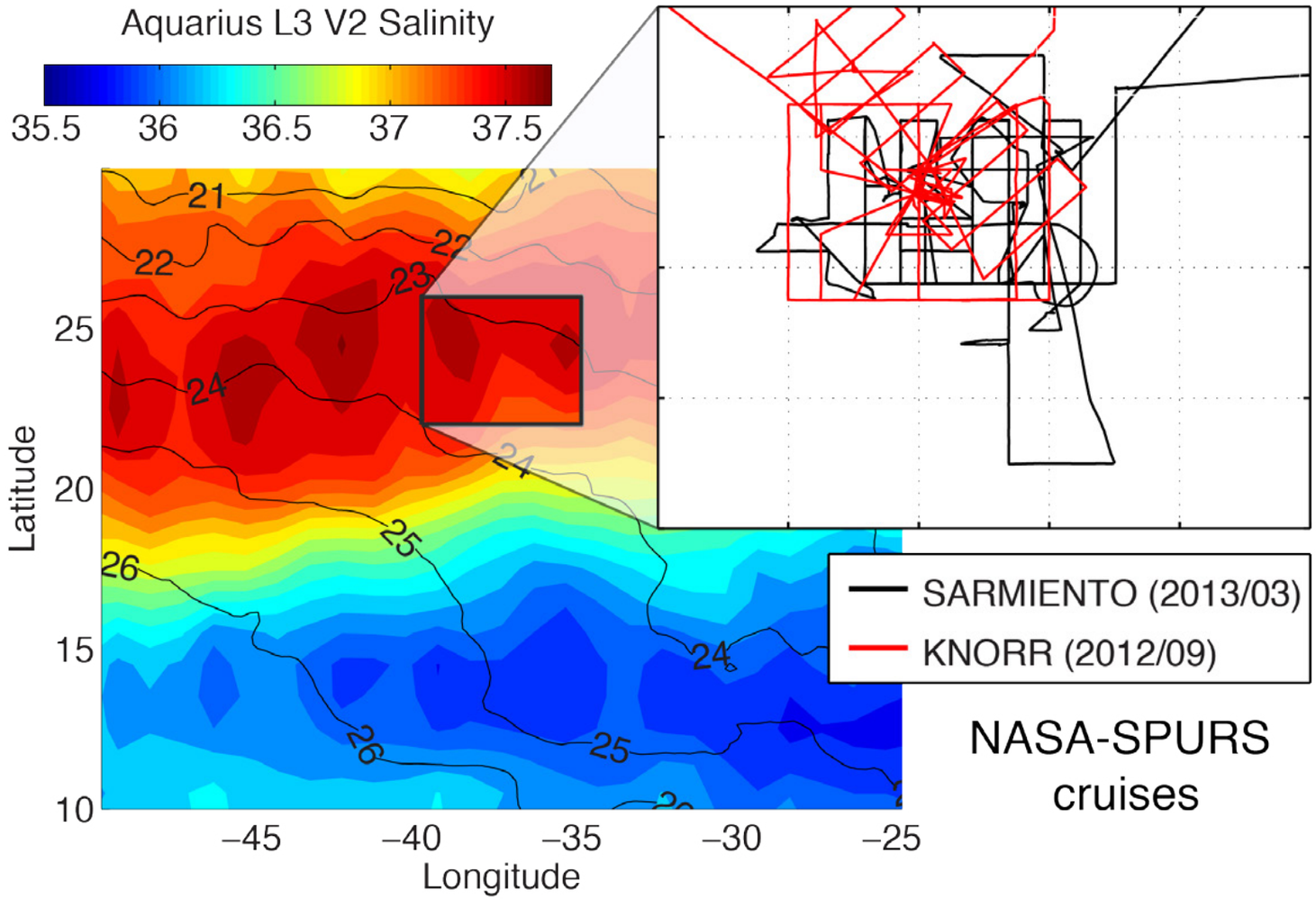
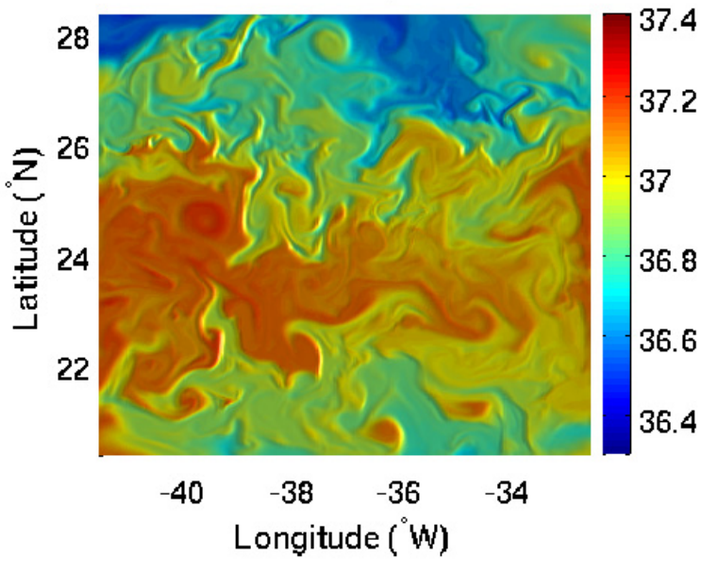
Introduction and Motivation



NASA-SPURS cruises



ROMS
Surface Salinity

The global freshwater cycle

- Sea surface salinity (SSS) as indicator for net evaporation
- Ocean processes are important to correctly interpret the freshwater cycle

The subtropical North Atlantic

- High variability in SSS
- Freshwater influx needed to balance net evaporation
- Which processes are significantly influencing the influx of freshwater? What shapes the variability in SSS?

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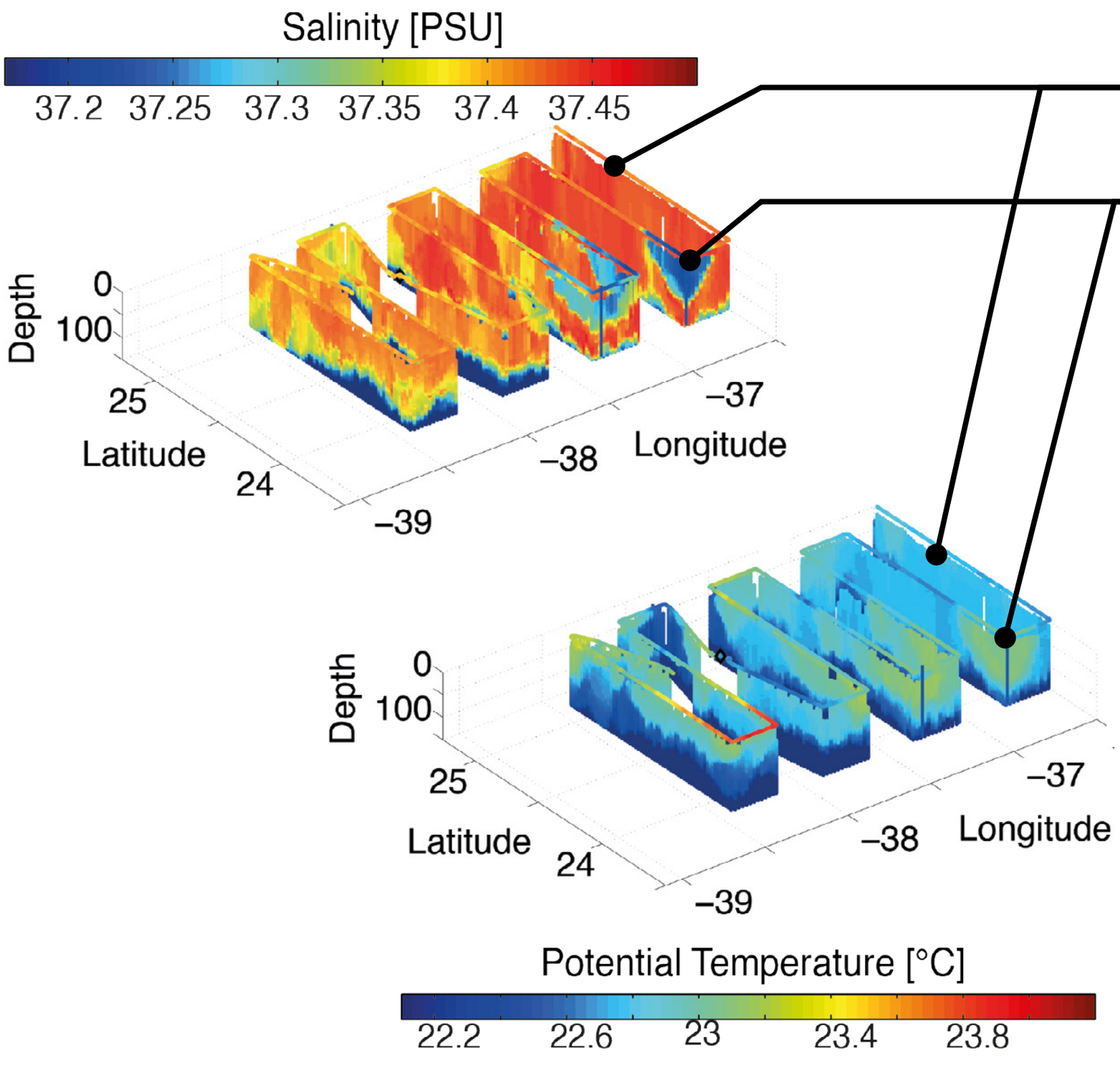
SeaSoar/TSG Survey



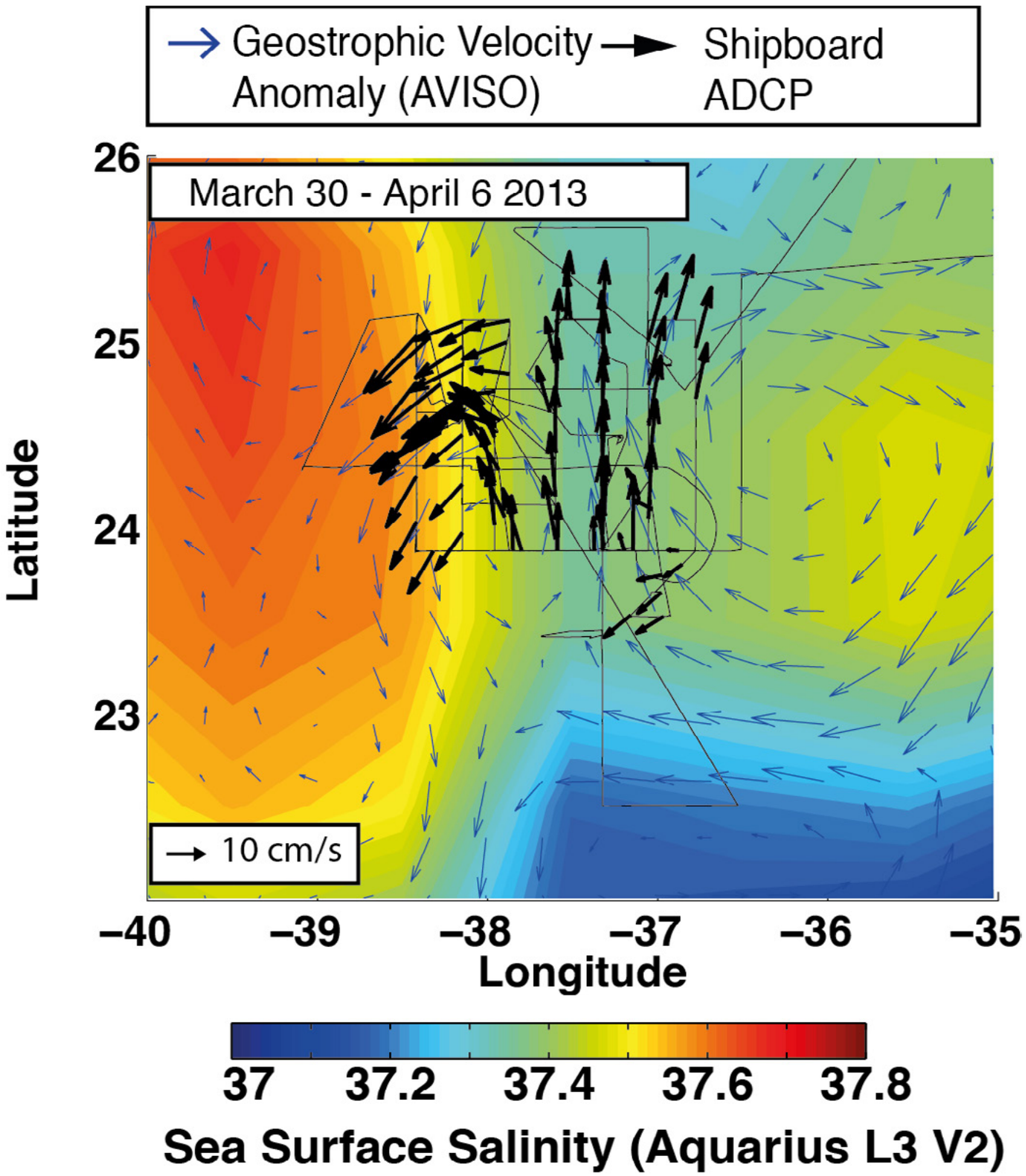
Prominent Features

- Deep salty mixed layers match climatology
- Fresh/warm features with strong surface fronts (>0.15 PSU/0.4 °C over less than 10 km)

Time Evolution

- Northward migration, filamentation and weakening
- Feature does not leave the domain
- Evaporation can not explain this behaviour
  - **Fresh water is added to mixed layer in the domain**

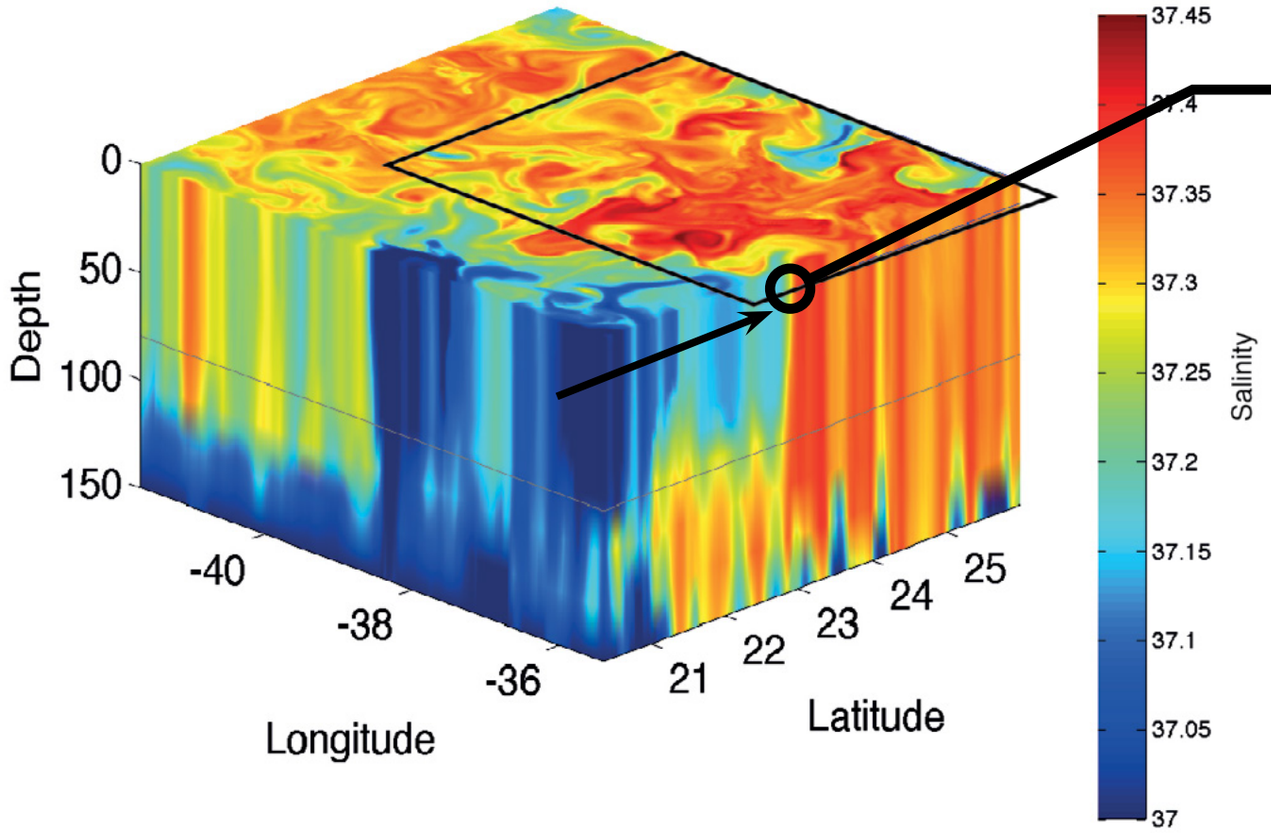
Origin of the fresh/warm feature



Satellite Data

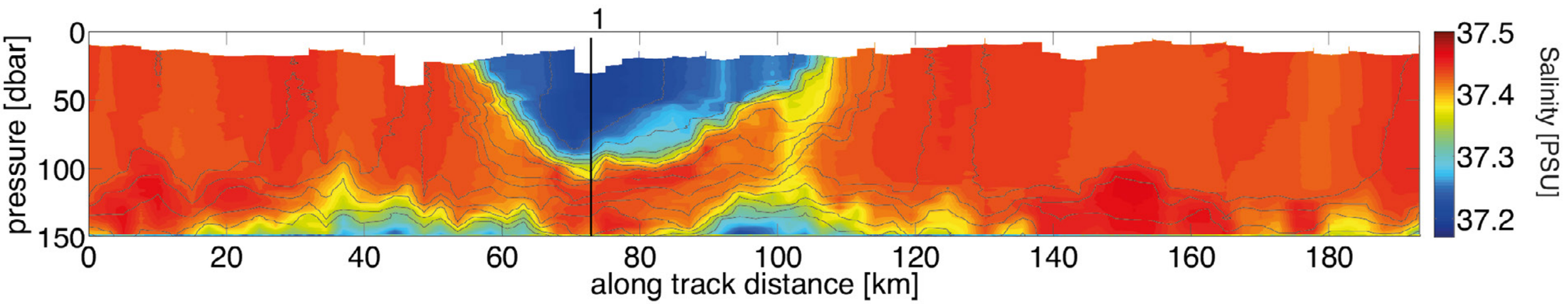
- Not a local rain event (TRMM)
- Fresher water detected in the south
  - **Feature originates from a larger body of water to the south**
- Geostrophic velocities agree with shipboard velocities
- Horizontal scale ~ 1st baroclinic Rossby radius
- Two features in one month, suggesting regular occurrence
- Elevated EKE collocated with source region
  - **Mesoscale turbulence could be important for the total freshwater flux into the region**

Regional model output

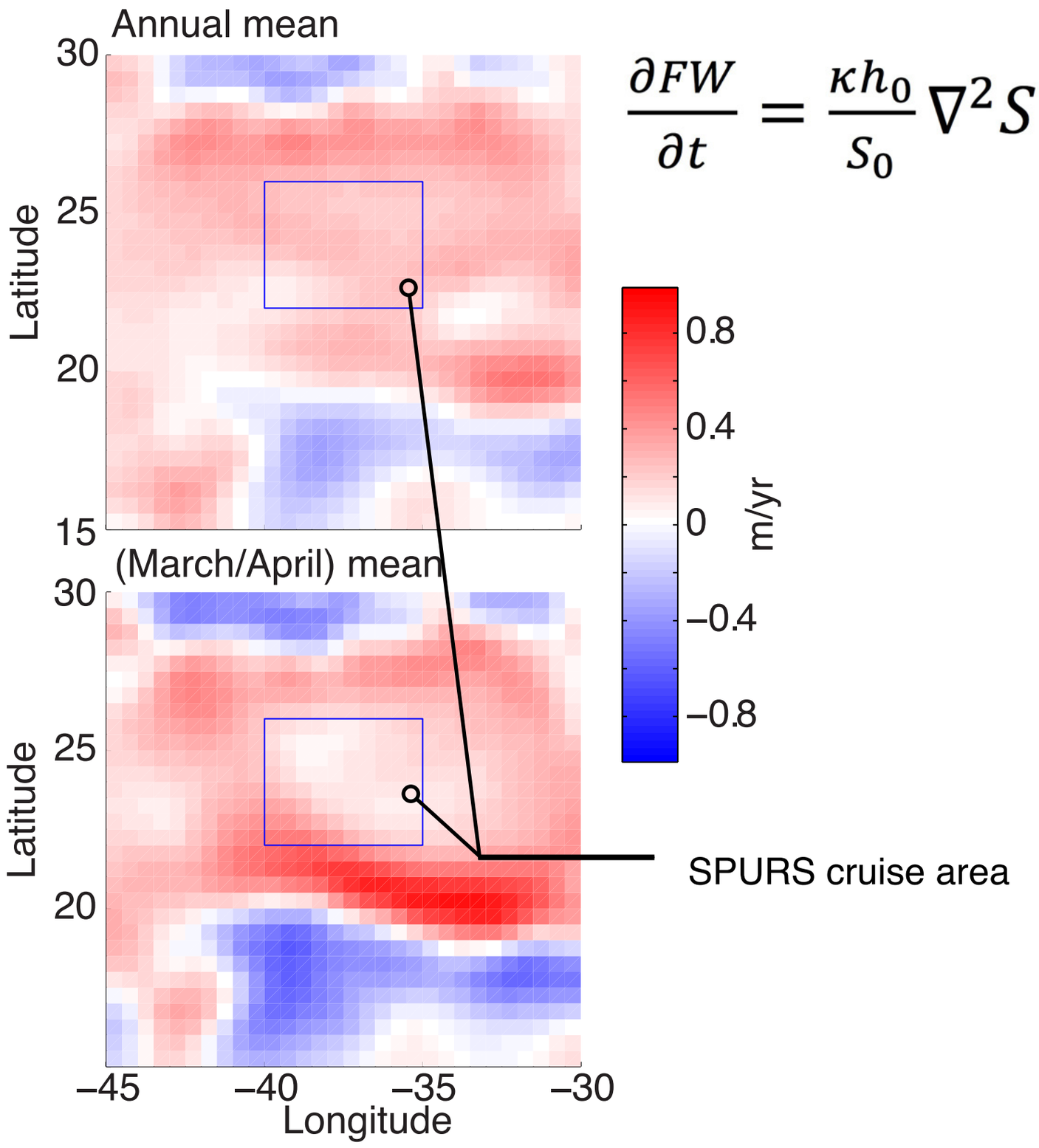


Comparison with survey data

- ROMS (2km resolution) reproduces an abundance of similar fresh features
- Lateral/vertical dimensions and surface characteristics are very similar to the in-situ data
- Northward advection from a fresh/warm body of water
- Fresh feature is dissipated on comparable time scale (~14-18 days)



Relevance for the SSS-max

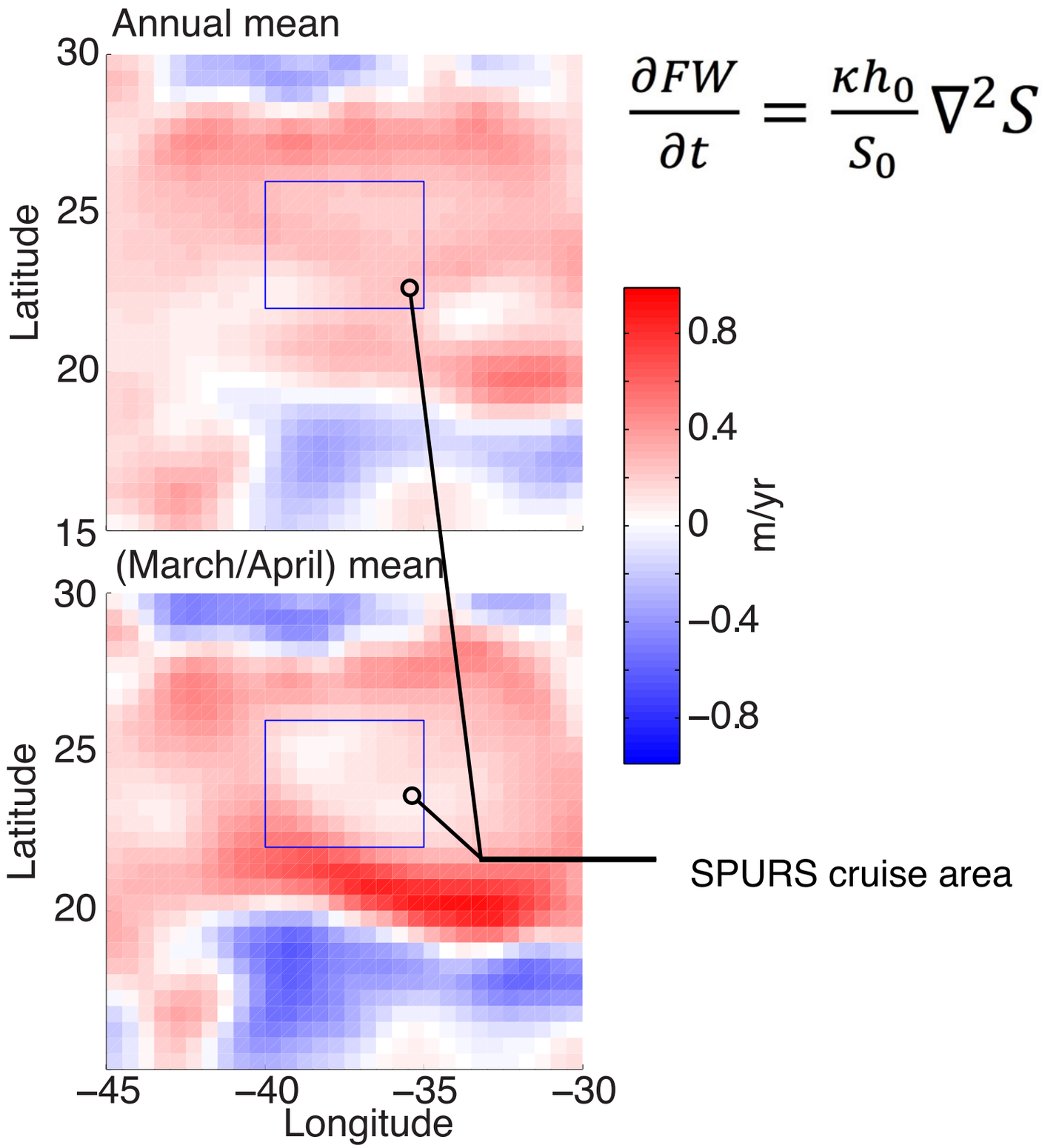


$$\frac{\partial FW}{\partial t} = \frac{\kappa h_0}{S_0} \nabla^2 S$$

Estimation of freshwater convergence by eddy diffusion

- Constant K=2000 m^2/s; [Abernathey and Marshall 2013])
- h_0 = 50 m (~ depth of fresh features)
- S_0 = 37.2 PSU
- S fields based on MIMOC Argo-Climatology

Relevance for the SSS-max

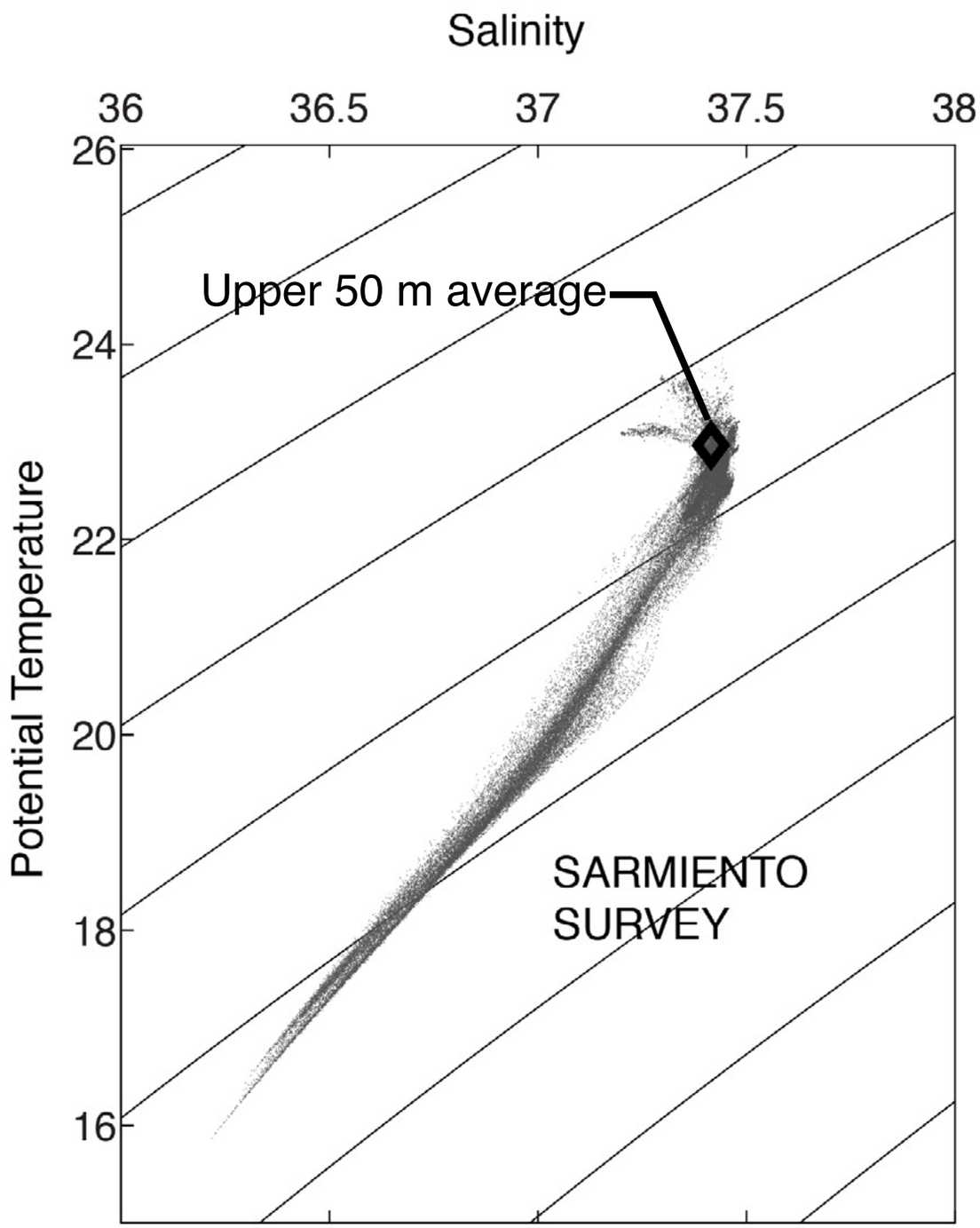


$$\frac{\partial FW}{\partial t} = \frac{\kappa h_0}{S_0} \nabla^2 S$$

Results

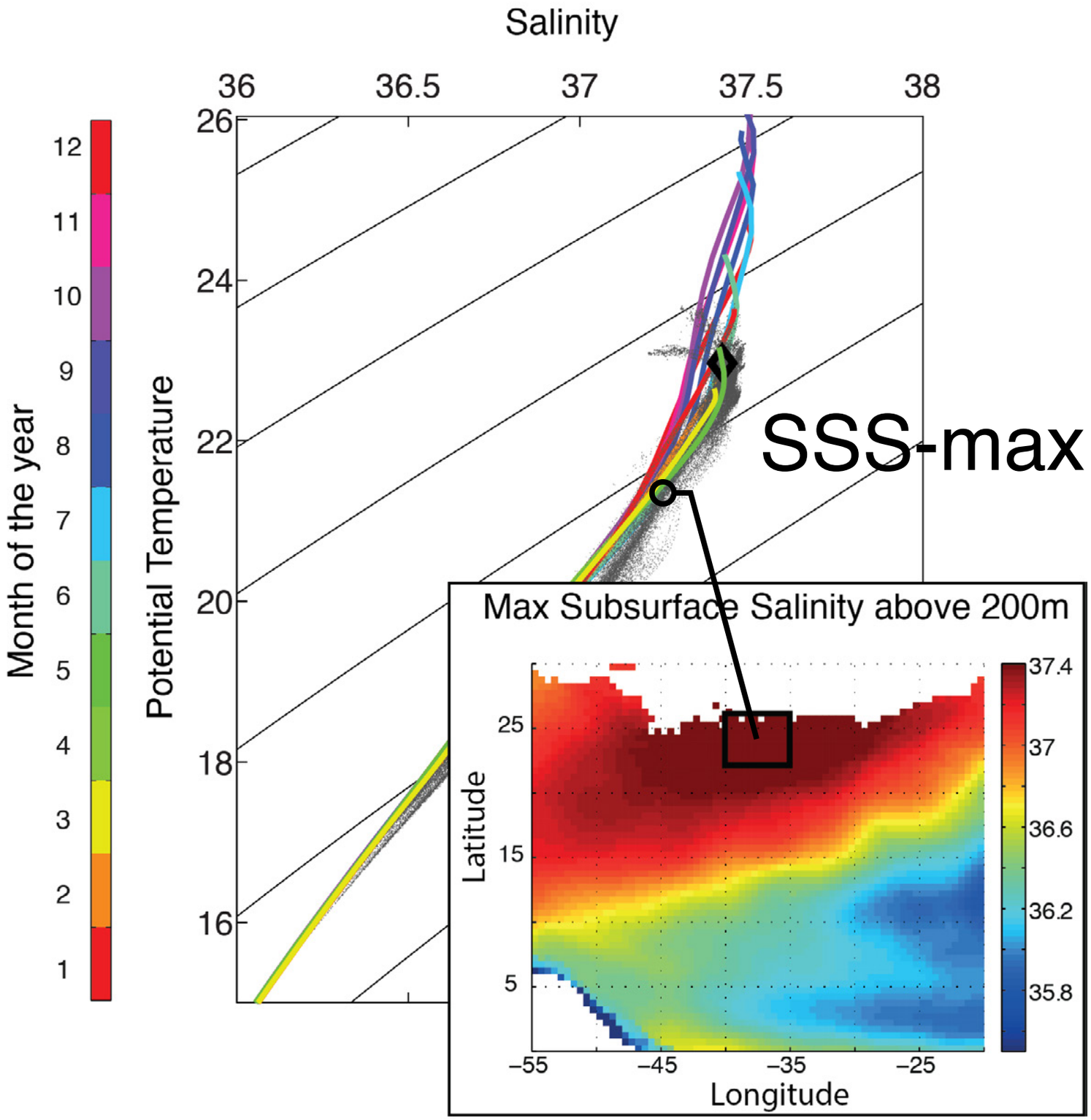
- 20-40% of the net evaporation can be balanced by eddy fluxes annually (mean E-P ~1 m/yr [Gordon and Giulivi, in review])
- Seasonally the influence seem even bigger
  - **The influence of this process is not negligible**

Connection to the subsurface salinity maximum



Comparison with MIMOC-Argo climatology

Connection to the subsurface salinity maximum



Comparison with MIMOC-Argo climatology

- Close match to the observed ‘salty and deep’ mixed layers
- Observed fresh features deviate strongly from the climatology

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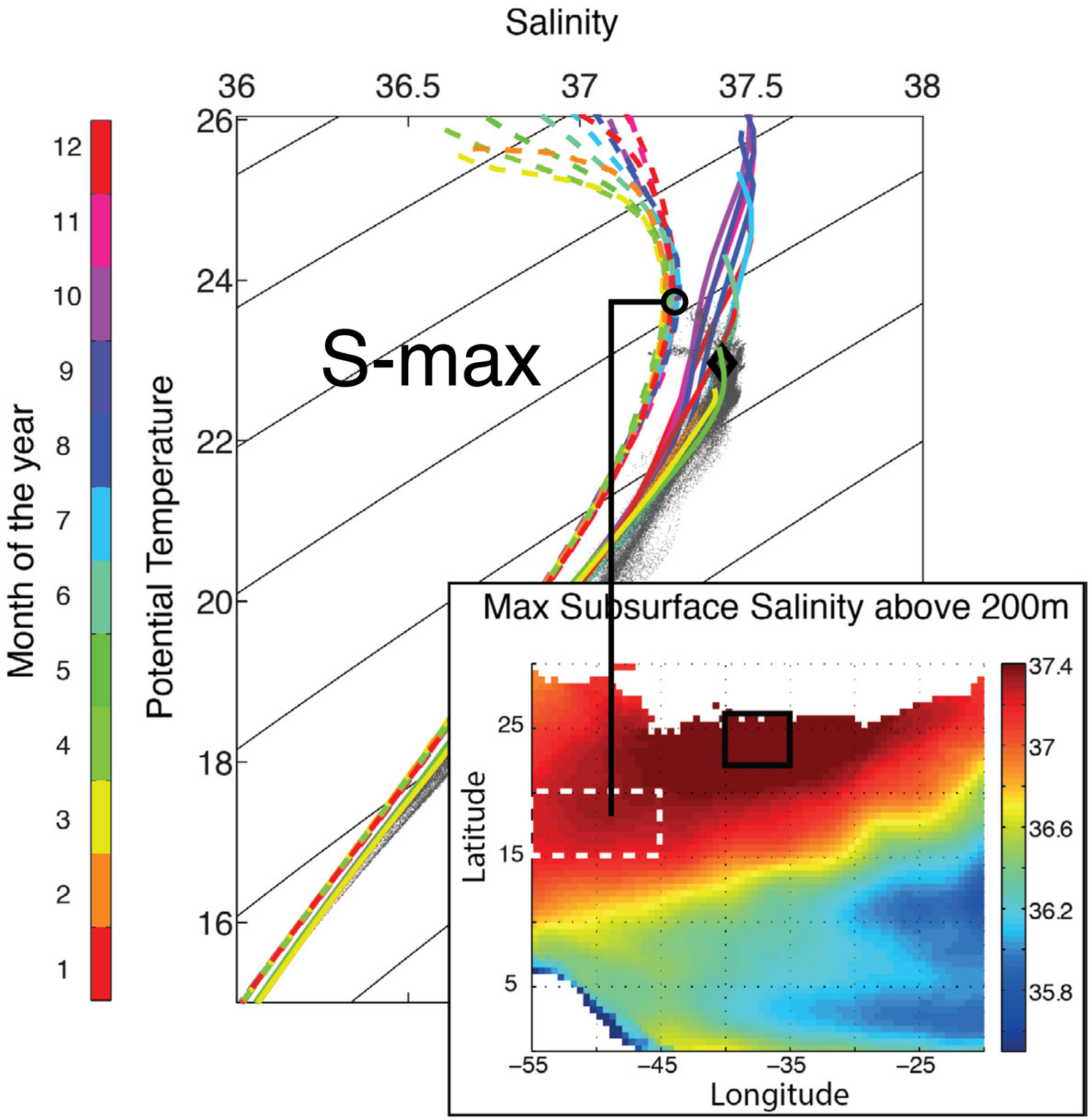
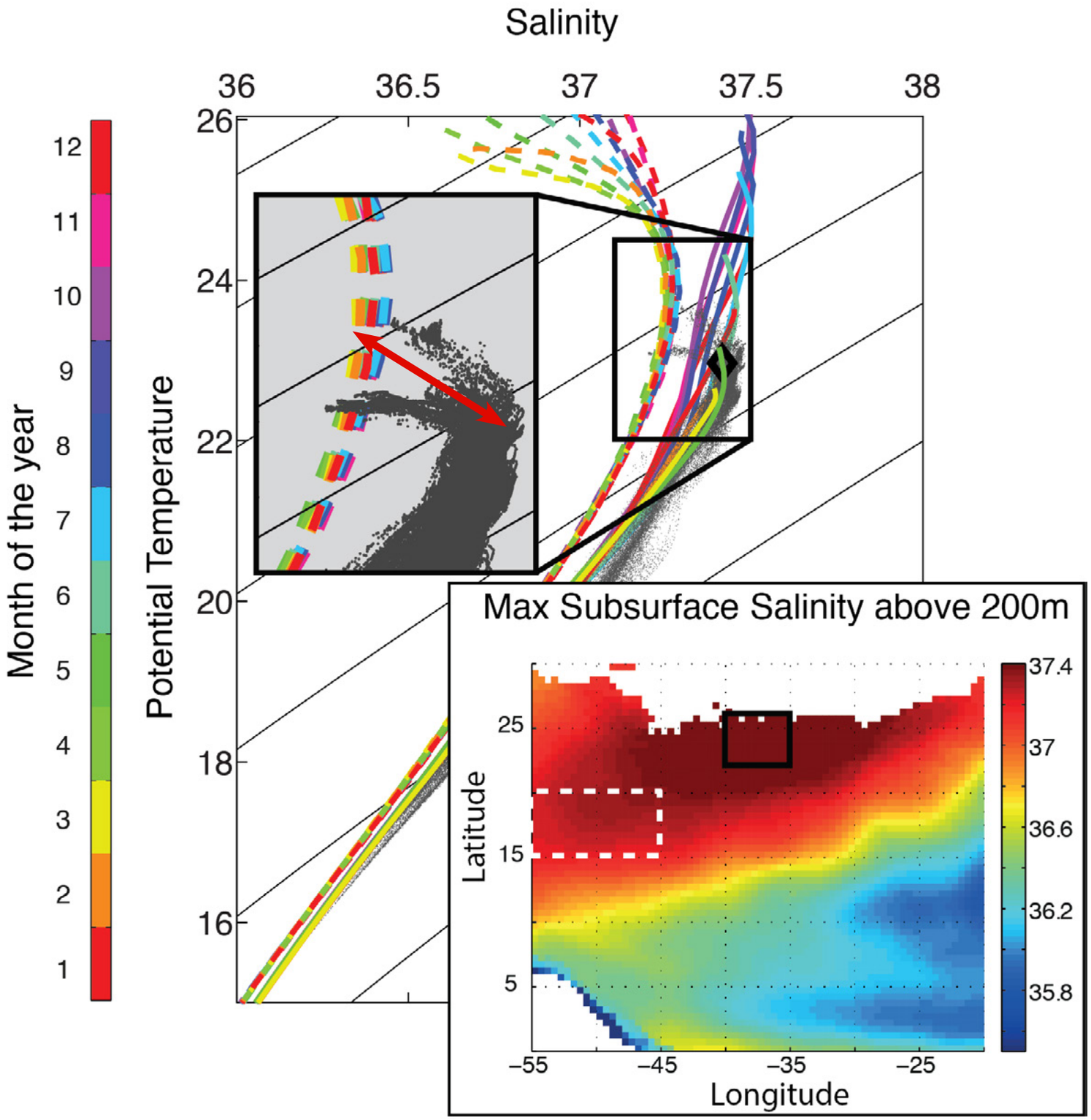
Connection to the subsurface salinity maximum



Comparison with MIMOC-Argo climatology

- Close match to the observed ‘salty and deep’ mixed layers
- Observed fresh features deviate strongly from the climatology
- SSS-max is too salty and cold to be exported as subsurface salinity maximum (S-max) via isopycnal pathways

Connection to the subsurface salinity maximum



Relevance to the shallow overturning circulation:

- Fresh features connect SSS-max and S-max
  - **Mesoscale turbulence modifies the SSS and by that might change the properties of the water that gets subducted**

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Conclusions

- **1. Highly variable surface salinity fields with pronounced fresh/warm features are documented**
- **2. The observed fresh/warm feature present a significant influx of freshwater**
- **3. Importance of lateral freshwater flux by mesoscale turbulence to the region**
- **4. Water mass characteristics suggest importance for the subsurface salinity maximum, hence the shallow overturning circulation**

Future Work

- **Expand eddy diffusion estimate in time and space to resolve interannual variability**

- **Investigate the upper limb of the shallow overturning circulation, specifically the role that mesoscale turbulence plays in the northward transport of fresh water and how this relates to wind, Ekman transport, regional E-P and SSS.**